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Date of Signature and Deposit: March 24, 2004

Attorney of Record

OIPE JC80 MAR 30 2004 PATENT & TRADEMARK OFFICE

PATENT

Docket No. 121812.00004

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Xiao

Appl. No: 10/731,363

Filing Date: December 9, 2003

Title: METHOD OF SEGMENTING A RE-ORDERING BUFFER OF WCMDA HSDPA SYSTEM AND MAPPING DATA THERETO

Group Art: 2127

CLAIM TO FOREIGN PRIORITY

Mail Stop MISSING PARTS
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P.O. Box 1450
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Sir:

Claim to foreign priority, based on Singapore Patent Application No. 200207478-9, filed December 10, 2002 is hereby lodged under 35 U.S.C. §119. A certified copy of the foreign priority document is submitted herewith.

No additional fee is believed to be due, but if any fee needs to be credited or charged, please charge Deposit Account No. 17-0055.

Respectfully submitted,

By: _____

Michael J. McGovern
Quarles and Brady LLP
411 East Wisconsin Ave.
Milwaukee, WI 53202
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Attorney of Record

REGISTRY OF PATENTS
SINGAPORE

This is to certify that the annexed is a true copy of application as filed for the following Singapore patent application.

Date of Filing	:	10 DECEMBER 2002
Application Number	:	200207478-9
Applicant(s) / Proprietor(s) of Patent	:	OKI TECHNO CENTRE (SINGAPORE) PTE LTD
Title of Invention	:	A METHOD OF SEGMENTING A RE-ORDERING BUFFER OF WCDMA HSDPA SYSTEM AND MAPPING DATA THERETO

SHARMAINE WU (Ms)
Assistant Registrar
for REGISTRAR OF PATENTS

ACTION

PATENTS FORM 1
Patents Act
(Cap. 221)
Patents Rules
Rule 19

INTELLECTUAL PROPERTY OFFICE OF SINGAPORE

REQUEST FOR THE GRANT OF A PATENT UNDER SECTION 25

101101

* denotes mandatory fields

1. YOUR REFERENCE* SP5270

2. TITLE OF INVENTION* A METHOD OF SEGMENTING A RE-ORDERING BUFFER OF WCDMA HSDPA SYSTEM AND MAPPING DATA THERETO

3. DETAILS OF APPLICANT(S)* (see note 3) Number of applicant(s): 1

(A) Name: Oki Techno Centre (Singapore) Pte Ltd

Address: 10 Collyer Quay #19-08 Ocean Building
Singapore 049315

State: Country: SG

[X] For corporate applicant [ ] For individual applicant

State of incorporation: State of residency:

Country of incorporation: SG Country of residency:

[ ] For others (please specify in the box provided below)

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(B) Name:

Address:

State: Country:

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10 DEC 2002

G00001

☐ For corporate applicant ☐ For individual applicant

State of incorporation | State of residency

Country of incorporation | Country of residency

☐ For others (please specify in the box provided below)

(C) Name

Address

State | Country

☐ For corporate applicant ☐ For individual applicant

State of incorporation | State of residency

Country of incorporation | Country of residency

☐ For others (please specify in the box provided below)

☐ Further applicants are to be indicated on continuation sheet 1

4. DECLARATION OF PRIORITY (see note 5)

A. Country/country designated

File number | Filing Date (DD MM YYYY)

B. Country/country designated

File number | Filing Date (DD MM YYYY)

☐ Further details are to be indicated on continuation sheet 6

5. INVENTOR(S)* (see note 6)

A. The applicant(s) is/are the sole/joint inventor(s) Yes ☐ No ☒

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10 DEC 2002

B. A statement on Patents Form 8 is/will be furnished Yes [X] No [ ]

6. CLAIMING AN EARLIER FILING DATE UNDER (see note 7)

[ ] section 20(3) [ ] section 26(6) [ ] section 47(4)

Patent application number

DD MM YYYY

Filing Date

Please mark with a cross in the relevant checkbox provided below
(Note: Only one checkbox may be crossed.)

[ ] Proceedings under rule 27(1)(a)

DD MM YYYY

Date on which the earlier application was amended

[ ] Proceedings under rule 27(1)(b)

7. SECTION 14(4)(C) REQUIREMENTS (see note 8)

Invention has been displayed at an international exhibition. Yes [ ] No [X]

8. SECTION 114 REQUIREMENTS (see note 9)

The invention relates to and/or used a micro-organism deposited for the purposes of disclosure in accordance with section 114 with a depository authority under the Budapest Treaty.

Yes [ ] No [X]

9. CHECKLIST*

(A) The application consists of the following number of sheets

i.	Request	5	Sheets
ii.	Description	12	Sheets
iii.	Claim(s)	2	Sheets
iv.	Drawing(s)	1	Sheets
v.	Abstract (Note: The figure of the drawing, if any, should accompany the abstract)	1	Sheets
Total number of sheets		21	Sheets

(B) The application as filed is accompanied by:

[ ] Priority document(s) [ ] Translation of priority document(s)

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X	Statement of inventorship & right to grant		International exhibition certificate

10. DETAILS OF AGENT (see notes 10, 11 and 12)

Name	
Firm	LLOYD WISE

11. ADDRESS FOR SERVICE IN SINGAPORE* (see note 10)

Block/Hse No.		Level No.		Unit No./PO Box	

Street Name	P.O BOX 636
Building Name	TANJONG PAGAR POST OFFICE
Postal Code	910816

12. NAME, SIGNATURE AND DECLARATION (WHERE APPROPRIATE) OF APPLICANT OR AGENT* (see note 12)
(Note: Please cross the box below where appropriate.)

X I, the undersigned, do hereby declare that I have been duly authorised to act as representative, for the purposes of this application, on behalf of the applicant(s) named in paragraph 3 herein.

Name and Signature LLOYD WISE

DD MM YYYY
10 12 2002

Our Ref: SP5270

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NOTES:

1. This form when completed, should be brought or sent to the Registry of Patents together with the rest of the application. Please note that the filing fee should be furnished within the period prescribed.

2. The relevant checkboxes as indicated in bold should be marked with a cross where applicable.

3. Enter the name and address of each applicant in the spaces provided in paragraph 3.
   Where the applicant is an individual
   - Names of individuals should be indicated in full and the surname or family name should be underlined.
   -The address of each individual should also be furnished in the space provided.
   - The checkbox for "For individual applicant" should be marked with a cross.

   Where the applicant is a body corporate
   - Bodies corporate should be designated by their corporate name and country of incorporation and, where appropriate, the state of incorporation within that country should be entered where provided.
   - The address of the body corporate should also be furnished in the space provided.
   - The checkbox for "For corporate applicant" should be marked with a cross.

   Where the applicant is a partnership
   - The details of all partners must be provided. The name of each partner should be indicated in full and the surname or family name should be underlined.
   - The address of each partner should also be furnished in the space provided.
   - The checkbox for "For others" should be marked with a cross and the name and address of the partnership should be indicated in the box provided.

4. In the field for "Country", please refer to the standard list of country codes made available by the Registry of Patents and enter the country code corresponding to the country in question.

5. The declaration of priority in paragraph 4 should state the date of the previous filing, the country in which it was made, and indicate the file number, if available. Where the application relied upon in an International Application or a regional patent application e.g. European patent application, one of the countries designated in that application [being one falling under section 17 of the Patents Act] should be identified and the country should be entered in the space provided.

6. Where the applicant or applicants is/are the sole inventor or the joint inventors, paragraph 5 should be completed by marking with a cross the 'YES' checkbox in the declaration (A) and the 'NO' checkbox in the alternative statement (B). Where this is not the case, the 'NO' checkbox in declaration (A) should be marked with a cross and a statement will be required to be filed on Patents Form 8.

7. When an application is made by virtue of section 20(3), 26(6) or 47(4), the appropriate section should be identified in paragraph 6 and the number of the earlier application or any patent granted thereon identified. Applicants proceeding under section 26(6) should identify which provision in rule 27 they are proceeding under. If the applicants are proceeding under rule 27(1)(a), they should also indicate the date on which the earlier application was amended.

8. Where the applicant wishes an earlier disclosure of the invention by him at an International Exhibition to be disregarded in accordance with section 14(4)(c), then the 'YES' checkbox at paragraph 7 should be marked with a cross. Otherwise, the 'NO' checkbox should be marked with a cross.

9. Where in disclosing the invention the application refers to one or more micro-organisms deposited with a depository authority under the Budapest Treaty, then the 'YES' checkbox at paragraph 8 should be marked with a cross. Otherwise, the 'NO' checkbox should be marked with a cross. Attention is also drawn to the Fourth Schedule of the Patents Rules.

10. Where an agent is appointed, the fields for "DETAILS OF AGENT" and "ADDRESS FOR SERVICE IN SINGAPORE" should be completed and they should be the same as those found in the corresponding Patents Form 41. In the event where no agent is appointed, the field for "ADDRESS FOR SERVICE IN SINGAPORE" should be completed, leaving the field for "DETAILS OF AGENT" blank.

11. In the event where an individual is appointed as an agent, the sub-field "Name" under "DETAILS OF AGENT" must be completed by entering the full name of the individual. The sub-field "Firm" may be left blank. In the event where a partnership/body corporate is appointed as an agent, the sub-field "Firm" under "DETAILS OF AGENT" must be completed by entering the name of the partnership/body corporate. The sub-field "Name" may be left blank.

12. Attention is drawn to sections 104 and 105 of the Patents Act, rules 90 and 105 of the Patents Rules, and the Patents (Patent Agents) Rules 2001.

13. Applicants resident in Singapore are reminded that if the Registry of Patents considers that an application contains information the publication of which might be prejudicial to the defence of Singapore or the safety of the public, it may prohibit or restrict its publication or communication. Any person resident in Singapore and wishing to apply for patent protection in other countries must first obtain permission from the Singapore Registry of Patents unless they have already applied for a patent for the same invention in Singapore. In the latter case, no application should be made overseas until at least 2 months after the application has been filed in Singapore, and unless no directions had been issued under section 33 by the Registrar or such directions have been revoked. Attention is drawn to sections 33 and 34 of the Patents Act.

14. If the space provided in the patents form is not enough, the additional information should be entered in the relevant continuation sheet. Please note that the continuation sheets need not be filed with the Registry of Patents if they are not used.

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A Method of Segmenting a Re-ordering Buffer of WCDMA HSDPA System and Mapping Data Thereto

FIELD OF THE INVENTION

This invention relates to a method of segmenting a re-ordering buffer and mapping data thereto, and more particularly, but not exclusively, relates to a method of segmenting a re-ordering buffer in a WCDMA HSDPA system and mapping TTI data to the buffer.

BACKGROUND OF THE INVENTION

HSDPA (High Speed Downlink Packet Access) is based on techniques such as adaptive modulation and hybrid ARQ (automatic repeat request) to achieve high throughput, reduce delay and achieve high peak rates. The new functionality of hybrid ARQ is involved in a MAC (Medium Access Control) layer which is just above a physical layer. The MAC layer is used to pass data received from the physical layer to an upper layer. A transport channel that the HSDPA functionality uses is called HS-DSCH (High Speed Downlink Shared Channel) and is controlled by the MAC-hs entity which is a part of MAC layer. There is only one MAC-hs entity in a UE (User Equipment).

The WCDMA HSDPA system uses a HARQ (hybrid automatic repeat request) entity to handle up to 8 HARQ processes for a UE, in which each process is independent and assigned an ID which represents one priority. Because of multi- and independent HARQ operation, it is possible to receive out-of-order TTI data in the downlink (UE side). Here, TTI data, i.e., transmission time interval data, is the data that the UE receives from the downlink within a prescribed transmission time interval. In a WCDMA HSDPA system, the above trasnmission time interval is 2ms. However, the upper layer still must receive in-order TTI data, so there is a re-ordering entity in the MAC-hs to organize the out-of-order TTI data received from the HARQ entity and deliver the re-ordered data to the upper layer. The re-ordering entity in the MAC-hs includes a re-

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ordering buffer for buffering and organizing the out-of-order TTI data under control from a controller in the MAC-hs. Logically, the re-ordering buffer is comprised of up to 8 re-ordering sub-buffers (namely, 8 re-ordering queues) to handle the out-of-order TTI data from the 8 HARQ processes.

The re-ordering buffer in the HSDPA system needs to prepare up to 8 re-ordering queues to handle the out-of-order TTI data from the HARQ entity, where each queue contains up to 32 out-of-order TTI data. The maximum length of each TTI data is N bits, where N depends on which class a UE supports. For example, if the UE supports a 3.6Mb/s class, the max TTI data size, N, equals 7300 bits and there is a total of 6 re-ordering queues in the re-ordering buffer.

In the prior art, two algorithms of memory allocation and disposal are widely used, namely, the static algorithm and the dynamic algorithm.

In the static algorithm, the memory is composed of multiple equally-sized blocks which are large enough to store received TTI data of any size, as specified in the specification 3GPP TS 25.308. Therefore, using the static algorithm, a re-ordering buffer needs to prepare as many blocks as the maximum number of the received out-of-order TTI data. For the above 3.6 Mb/s class, the buffer has to prepare 6×32 blocks, each of the size of 7300 bits. In other words, the total buffer size for the static algorithm soars to 6×32×7300 bits = 1388.75 Kb. Unfortunately, it is not affordable for hardware implementation.

In the dynamic algorithm there are no blocks of pre-defined size in the memory, and each memory-allocation is based on the size of the TTI data which needs to be stored. More specifically, in the dynamic algorithm, there are no fixed size blocks in the buffer and the TTI data are stored in the buffer sequentially. A store address for each of the TTI data depends upon the address of the last stored TTI data. When the buffer releases one TTI data which is stored in the middle part of the buffer, all of the TTI data stored thereafter needs to be moved up so as to fill the obsolete space left by the released data. Theoretically, the

above process is called Garbage Collection. It can be seen that although the dynamic algorithm can reduce the total buffer size, it requires huge processing time to do the garbage collection to reuse the obsolete space in the buffer.

Therefore, there is a need existing in the art to provide an efficient method of segmenting a re-ordering buffer in the WCDMA HSDPA system and to map TTI data thereto, which will not only reduce the necessary buffer size but save processing time. There are several difficulties in implementing such a re-ordering function. A simple algorithm for buffer segmentation and mapping reduces hardware complexity and consumes less hardware operation time, but it needs a large buffer size, which will increase the hardware cost. Alternatively, a complex algorithm requires a smaller buffer size, but at the cost of additional hardware complexity and slower hardware operation time. Thus, there is additionally a need for a method which will balance the hardware operation time, hardware complexity and total buffer size.

SUMMARY OF THE INVENTION

In accordance with first aspect of the present invention, there is provided a method of segmenting a re-ordering buffer in WCDMA HSDPA system, comprising the steps of: dividing the re-ordering buffer into multiple segments; dividing each segment into multiple blocks such that blocks within the same segment have the same size while the sizes of blocks located in separate segments are integer multiples of each other.

Typically, the multiple segments include a first, second and third segment.

Typically, the size of the blocks of the first segment is 2 times that of the second segment, and 4 times that of the third segment.

Preferably, the size of the blocks of the first segment is the maximum length of received TTI data.

Preferably, the size of the blocks of the first segment is half of the maximum length of received TTI data.

In accordance with second aspect of the present invention, there is provided a re-ordering buffer for storing TTI data in WCDMA HSDPA system, comprising multiple segments, wherein each segment is composed of multiple blocks with equal size, and the sizes of the blocks of a first segment of the multiple segments are integer multiples of the sizes of the blocks of additional segments of the multiple segments.

In accordance with third aspect of the present invention, there is provided a method of mapping TTI data to the above re-ordering buffer, comprising the steps of: determining a size category of the TTI data; comparing the size category of the TTI data with sizes of the blocks of the first segment and the additional segments to find a matching block for storing the TTI data; storing the TTI data in the matching block if an empty matching block is found, but if no empty matching block is found then: storing the TTI data in a block with a size larger than the size category of the TTI data; storing the TTI data in adjacent blocks, if such a block with a larger size is unavailable.

Preferably, the step of determining is based on the size of the TTI data and the sizes of the blocks of the segments.

Preferably, the step of storing the TTI data in a block with a larger size comprises the steps of: If a larger sized block is partially occupied but still has enough space for the TTI data, storing the data in the block; and If such a larger sized block is unavailable, storing the TTI data in a free block with a larger size.

Preferably, the step of storing the TTI data in adjacent blocks comprises a step of storing the TTI data in a minimum number of adjacent blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 schematically illustrates a segmentation structure of a re-ordering buffer at 3.6Mb/s UE class according to a first embodiment of the present invention; and

Fig. 2 schematically illustrates a segmentation structure of a re-ordering buffer at 3.6Mb/s UE class according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Although the present invention can be applied for any of the classes which UE supports, in order to explain the principle of the invention, the case of UE support of the 3.6Mb/s class during communication in the WCDMA HSDPA system is used as an example. Therefore, the maximum length of TTI data is 7300 bits. TTI data, or MAC-hs PDU (protocal data unit), comprises a MAC-hs header, MAC-hs SDUs (Service Data Unit) and a Padding (optional). What needs to be stored in the re-ordering buffer is MAC-hs SDUs and Padding. Thus, the maximum data size stored in the buffer is 7296 bits.

Fig. 1 schematically illustrates a segmentation structure of a re-ordering buffer at 3.6Mb/s UE class according to a first embodiment of the present invention. Under ideal channel conditions, TTI data is transmitted at high speed, and if the network has enough code resource, large-sized TTI data is expected to be sent to the UE. However, even if the network does not have enough code resource for the UE, it is still possible to send medium to small-sized TTI data to the UE. The number of TTI data to be stored in re-ordering buffer will be very small as there are few re-transmissions needed. Taking the above into consideration, in

the first embodiment, the re-ordering buffer is segmented into three segments, wherein each segment comprises multiple blocks with equal size. There is a close relationship among the sizes of the blocks of the three segments, namely, the size of the blocks of one segment is a multiple of the sizes of the blocks of the other segments. In the first embodiment, the size of the blocks of segment 1 is two times that of segment 2 and four times that of segment 3. Of course, any person skilled in the art can derive other variations, such as the size of the blocks of segment 1 can be three times of segment 2 and six times of segment 3, which falls within the scope of the invention.

Here, the blocks of segment 1 are referred as large blocks (L), those of segment 2 as medium blocks (M), and those of segment 3 as small blocks (S). Therefore, the sizes of the blocks of the three segments have the following relationship: 1*L=2*M=4*S, more specifically, the sizes of the blocks of segment 1, segment 2 and segment 3 can be 7296 bits, 3648 bits and 1824 bits, respectively.

Based on the segmentation structure of the re-ordering buffer according to the first embodiment, a rule for mapping one TTI data to the re-ordering buffer is defined as follows:

(1) Ranging the TTI data according to its size,

According to the method of the present embodiment, TTI data having a size of between 3649 bits and 7296 bits is ranged in the large category; TTI data having a size which is between 1825 bits and 3648 bits is ranged in the medium category; and TTI data having a size which is below 1824 bits is ranged in small category.

(2) Looking for one free block in a segment, the size of which matches that of TTI data to be buffered.

If the TTI data is ranged in the large category, then the matching block is a large block (L) in segment 1. If the TTI data is ranged in medium category, the matching block is a medium block (M) in segment 2. If the TTI data is ranged in small category, the matching block is a medium block (S) in segment 3.

(3) If (2) is unsuccessful, which means that all the matching blocks are full, then mapping the TTI data so that it shares a block with other data or occupies the fewest block(s) possible, more particularly,

(3-1) buffering large size TTI data,

(3-1-1) looking for two adjacent medium blocks in segment 2;

(3-1-2) if (3-1-1) is unavailable, looking for four adjacent small blocks in segment 3;

(3-2) buffering medium size TTI data,

(3-2-1) looking for a large block in segment 1 which is partially occupied, for example, occupied by another medium-size TTI data, and still has enough space for the TTI data;

(3-2-2) if (3-2-1) is unavailable, looking for a free large block in segment 1 and occupying half of the block;

(3-2-3) if (3-2-2) is unavailable, looking for two adjacent small blocks in segment 3.

(3-3) buffering small size TTI data,

(3-3-1) looking for a medium block in segment 2 which is partially occupied, i.e., occupied by another small-size TTI data, and still has enough space for the TTI data;

(3-3-2) if (3-3-1) is unavailable, looking for a free medium block in segment 2 and occupying half of the block;

(3-3-3) if (3-3-2) is unavailable, looking for a large block in segment 1 which is partially occupied and still has enough space for the TTI data, and occupying a front part of the space;

(3-3-4) if (3-3-3) is unavailable, looking for a free large block in segment 1 and occupying a first quarter of the block.

According to the specification, Joint RAN WG 1 and RAN WG 2 meeting on HSDPA technical document 12A010051 section 2.5.1, under ideal channel conditions, it is assumed that only one HARQ process, which is at the highest speed transmission, is active, and this is the maximum data size UE need to consider. Then, the re-ordering buffer size is calculated as N×16. Given that UE supports 3.6Mbps class, the re-ordering buffer size is 7300×16 bits.

Given the above, according to the method proposed in the first embodiment, the re-ordering buffer will be segmented as follows:
Segment 1: 7296×8 bits
Segment 2: 3648×8 bits
Segment 3: 1824×16 bits.

Using the mapping rules disclosed in this embodiment, the re-ordering buffer can buffer a total of 16 large TTI data, 32 medium TTI data, or 64 small TTI data, which is within the UE capability defined in the 3GPP specification.

With respect to Fig. 2, the second embodiment of the invention will be explained.

In the second embodiment, a variation of the first embodiment is considered. In practice, under bad channel conditions, medium to small TTI data is expected to be sent to the UE even if network has the code resource. And the number of TTI data to be stored in the re-ordering buffer will be a little larger, since a few re-transmissions are possible. Taking the above into consideration, in the second embodiment, the re-ordering buffer is segmented into three segments, wherein each segment comprises multiple blocks with equal size. There is close relationship among the sizes of the blocks of the three segments, namely, the sizes of the blocks of the three segments are multiple-related. In the second

embodiment, the size of the blocks of segment 1' is two times of segment 2' and four times of segment 3'.

Here, the blocks of segment 1' are referred as medium blocks (M), those of segment 2' as small blocks (S), and those of segment 3' as tiny blocks (T). Therefore, the sizes of the blocks of the three segments have the following relationship: 1*M=2*S=4*T, more specifically, the sizes of the blocks of segment 1', segment 2' and segment 3' can be 3648 bits, 1824 bits and 912 bits, respectively. Here, M and S are the same sizes as in the first embodiment. Using the definition of large block in the first embodiment, we can have following full relationship in terms of block size, 1*L=2*M=4*S=8*T.

Based on the segmentation structure of the re-ordering buffer according to the second embodiment, a rule for mapping one TTI data to the re-ordering buffer is defined as follows:

(1') Ranging the TTI data according to its size,

According to the method of the present embodiment, the TTI data having a size of between 3649 bits and 7296 bits is ranged in large category; the TTI data having a size of between 1825 bits and 3648 bits is ranged in medium category; the TTI data having a size of between 912 and 1824 bits is ranged in small category; and the TTI data having a size of below 912 bits is ranged in tiny category.

(2') If the TTI data to be buffered large in size, looking for two adjacent blocks in segment 1'; if not available, looking for four adjacent small blocks in segment 2'; if still not available, looking for eight adjacent tiny blocks in segment 3'.

(3') If the TTI data to be buffered is in another category (medium, small or tiny), looking for one free block in a segment, the size of which matches that of TTI data to be buffered.

If the TTI data is ranged in the medium category, then the matching block is a medium block (M) in segment 1'. If the TTI data is ranged in small category, the matching block is a small block (S) in segment 2'. If the TTI data is ranged in tiny category, the matching block is a tiny block (T) in segment 3'.

(4') If (3') is unsuccessful, which means that all the matching blocks are full, then mapping the TTI data so that it shares a block with other data or occupies as less block(s) as possible, more particularly,

(4'-1) for the TTI data to be buffered is medium size,

(4'-1-1) looking for two adjacent small blocks in segment 2';

(4'-1-2) if (4'-1-1) is unavailable, looking for four adjacent tiny blocks in segment 3';

(4'-2) when the TTI data to be buffered is small size,

(4'-2-1) looking for a medium block in segment 1' which is partially occupied, for example, occupied by another small-size TTI data, and which still has enough space for the TTI data;

(4'-2-2) if (4'-2-1) is unavailable, looking for a free medium block in segment 1' and occupying half of the block;

(4'-2-3) if (4'-2-2) is unavailable, looking for two adjacent tiny blocks in segment 3'.

(4'-3) when the TTI data to be buffered is tiny size,

(4'-3-1) looking for a small block in segment 2' which is partially occupied, i.e., occupied by another tiny-size TTI data, and still has enough space for the TTI data;

(4'-3-2) if (4'-3-1) is unavailable, looking for a free small block in segment 2' and occupying half of the block;

(4'-3-3) if (4'-3-2) is unavailable, looking for a medium block in segment 1' which is partially occupied and still has enough space for the TTI data, and occupying a front part of the space;

(4'-3-4) if (4'-3-3) is unavailable, looking for a free medium block in segment 1 and occupying a first quarter of the block.

Given that the buffer size is 7300×16 bits as specified in the above-mentioned specification, according to the method proposed in the first embodiment, the re-ordering buffer will be segmented as follows:

Segment 1': 3648×16 bits

Segment 2': 1824×16 bits

Segment 3': 912×32 bits.

Using the mapping rules disclosed in this embodiment, the re-ordering buffer can buffer 16 large TTI data, 32 medium TTI data, 64 small TTI data, or 128 tiny TTI data, in compliance with the re-ordering buffer specification requirements under bad channel conditions.

Under worse channel conditions, only small TTI data is expected to be sent to UE, and the number of TTI data stored in the re-ordering buffer is large, since all of the active re-ordering queues may need re-transmission at the same time. To achieve better performance without increasing the algorithm complexity, additional buffer size is considered. However, the method of segmenting and mapping remains the same as the first and second embodiments. The additional buffer size, ranging from 20%-25% of the re-ordering buffer size, will not introduce trade-off protocol performance.

ADVANTAGE OF THE INVENTION

Compared with the prior static algorithm, the method of segmenting and mapping of the present invention can store more TTI data. Taking the re-ordering buffer size of 7300×16 bits as an example, using the static algorithm, only 16 TTI data, no matter large, medium, small or tiny size, can be stored, while the re-ordering buffer of the present buffer can store 16 large, 32 medium, 64 small or 128 tiny TTI data.

Compared with the prior dynamic algorithm, the method of the present invention is easier and faster, since it does not need garbage collection, which reqires a long processing time.

In view of the description of the invention included herein, numerous additional embodiments and variations on the discussed embodiments of the present invention will be apparent to one of ordinary skill in the art. It is to be understood that such embodiments do not depart from the present invention and are to be considered within the scope of the invention.

CLAIMS:

1. A method of segmenting a re-ordering buffer in WCDMA HSDPA system, comprising the steps of:
dividing the re-ordering buffer into multiple segments;
dividing each segment into multiple blocks such that blocks within the same segment have the same size while the sizes of blocks located in separate segments are integer multiples of each other.

2. A method according to claim 1, wherein the multiple segments include a first, second and third segment.

3. A method according to claim 2, wherein the size of the blocks of the first segment is 2 times that of the second segment, and 4 times that of the third segment.

4. A method according to claim 3, wherein the size of the blocks of the first segment is the maximum length of received TTI data.

5. A method according to claim 3, wherein the size of the blocks of the first segment is half of the maximum length of received TTI data.

6. A re-ordering buffer for storing TTI data in WCDMA HSDPA system, comprising multiple segments, wherein each segment is composed of multiple blocks with equal size, and the sizes of the blocks of a first segment of the multiple segments are integer multiples of the sizes of the blocks of additional segments of the multiple segments.

7. A method of mapping TTI data to the re-ordering buffer of claim 6, comprising the steps of:
determining a size category of the TTI data;

comparing the size category of the TTI data with sizes of the blocks of the first segment and the additional segments to find a matching block for storing the TTI data;

storing the TTI data in the matching block if an empty matching block is found, but if no empty matching block is found then:

storing the TTI data in a block with a size larger than the size category of the TTI data;

storing the TTI data in adjacent blocks, if such a block with a larger size is unavailable.

8. A method according to claim 7, wherein the step of determining is based on the size of the TTI data and the sizes of the blocks of the segments.

9. A method according to claims 7 and 8, wherein the step of storing the TTI data in a block with a larger size comprises the steps of:

If a larger sized block is partially occupied but still has enough space for the TTI data, storing the data in the block; and

If such a larger sized block is unavailable, storing the TTI data in a free block with a larger size.

10. A method according to claims 7 and 8, wherein the step of storing the TTI data in adjacent blocks comprises a step of storing the TTI data in a minimum number of adjacent blocks.

ABSTRACT

A Method Of Segmenting A Re-ordering Buffer of WCDMA HSDPA System And Mapping Data Thereto

A method of segmenting a re-ordering buffer comprises: dividing the re-ordering buffer into multiple segments; dividing each segment into multiple blocks such that blocks within the same segment have the same size while the sizes of blocks located in separate segments are integer multiples of each other. A method of mapping TTI data to the re-ordering comprises: determining a size category of the TTI data; comparing the size category of the TTI data with sizes of the blocks of the segments to find a matching block for storing the TTI data; storing the TTI data in the matching block if an empty matching block is found, but if no empty matching block is found: storing the TTI data in a block with a size larger than the size category of the TTI data; storing the TTI data in adjacent blocks, if such a block with a larger size is unavailable.

FIGURE 1

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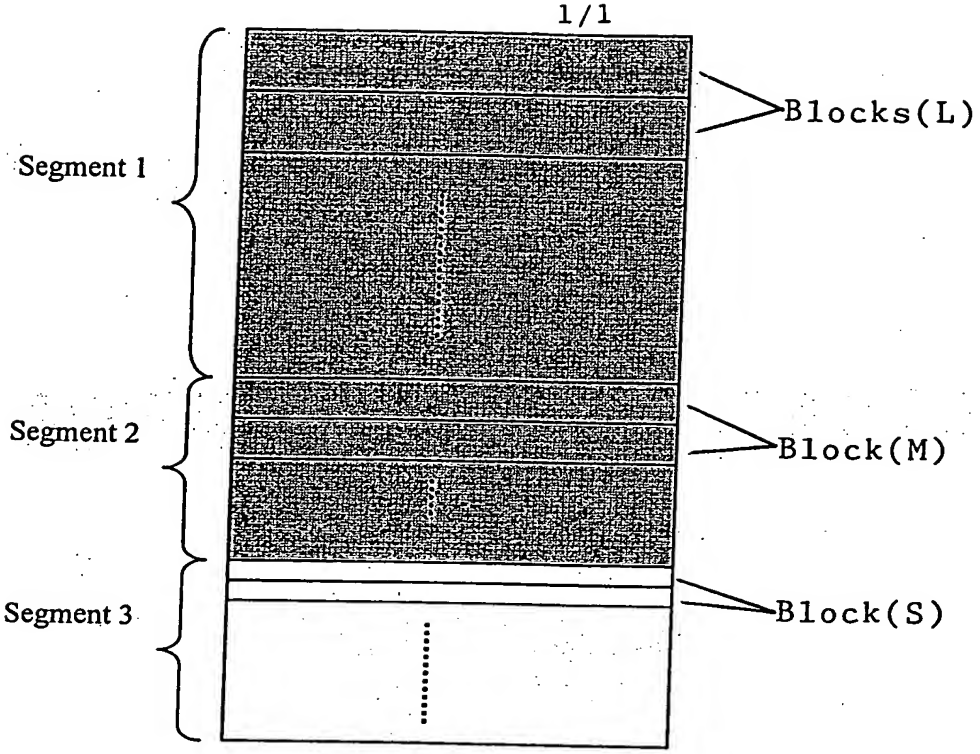

Figure 1

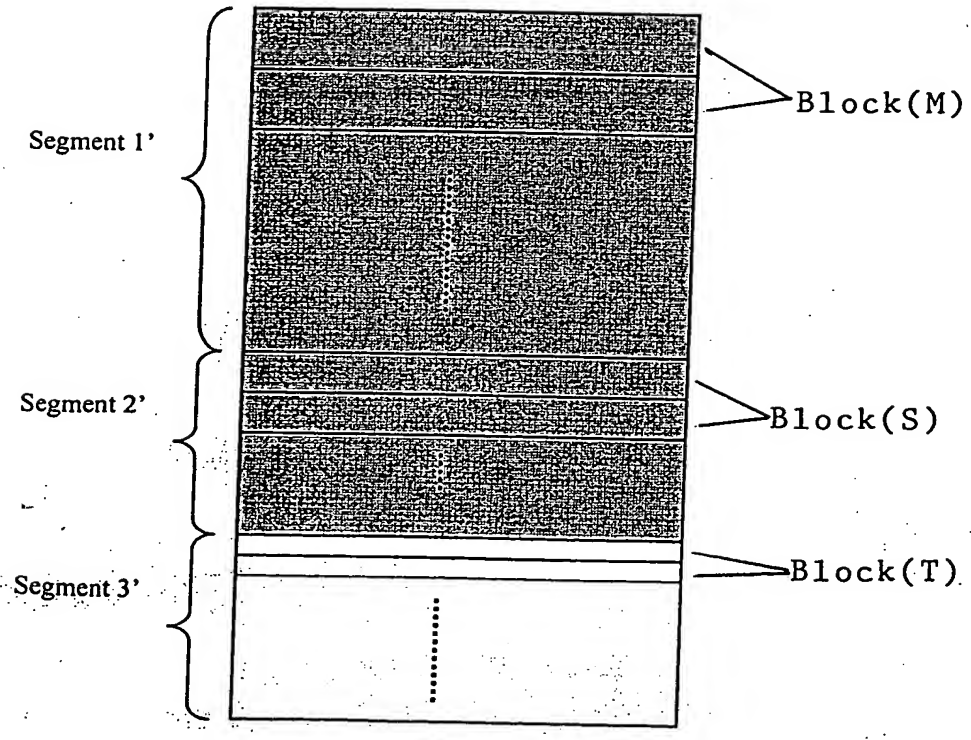

Figure 2